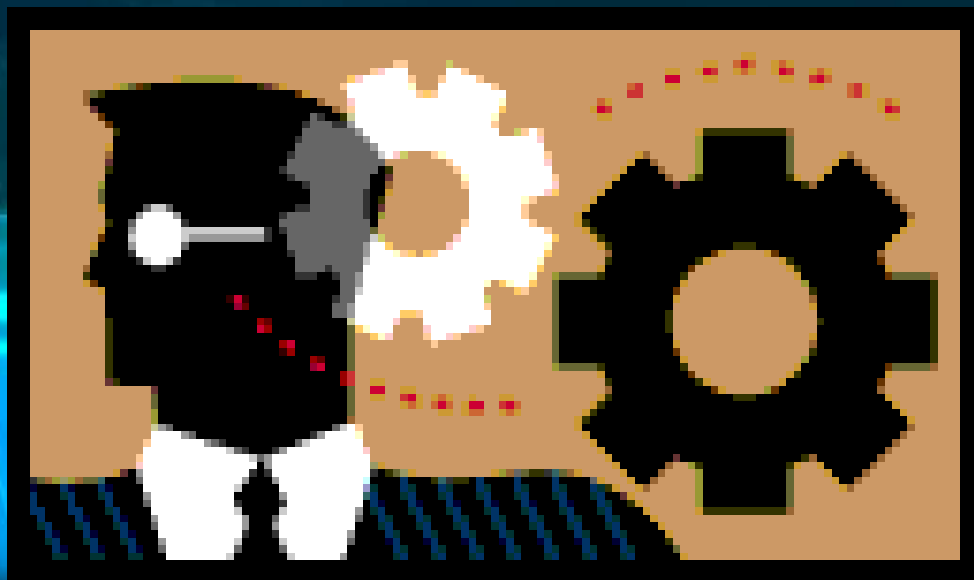
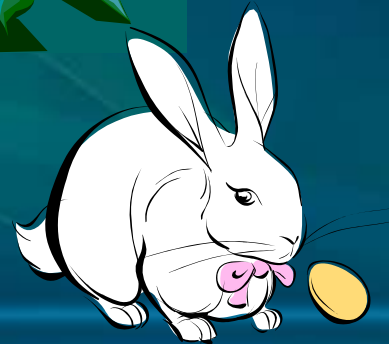
Basic Chemistry

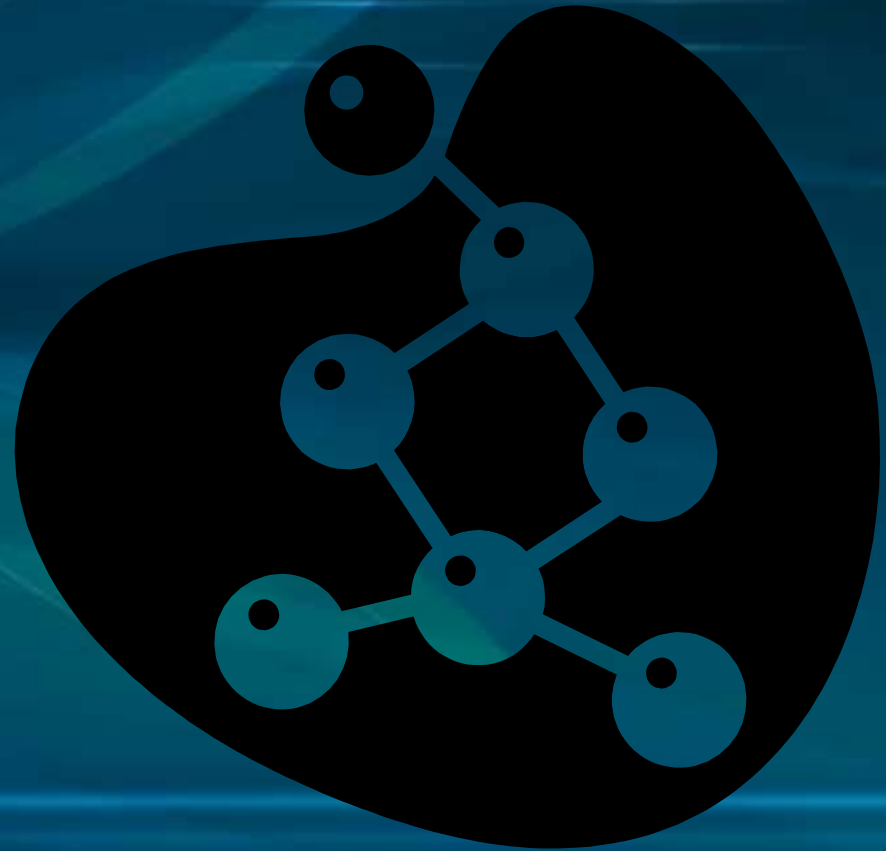
Chemistry is taking place in your body all the time. Your body is made up of a variety of chemicals, and chemical reactions that take place within you.

There is also chemistry taking place in plants, cows, rabbits, and every living thing.

To start at the very beginning, we need to start with the very small

The atom: The atom is the smallest particle of an **element** with a balanced electrostatic charge. It is also the smallest part that has the characteristics of that element.

What are Atoms?

- History of the atom
  - Democritus
    - 4th Century B.C.
    - Suggested that all matter in the universe was made up small particles called "atoms."
    - Atoms in Greek means "unable to be divided
  - John Dalton
    - 1808, School Teacher in England
    - Proposed an atomic theory which became widely accepted.

Dalton's Atomic Theory: Atoms are the Building Blocks of Molecules

- Every element is made up of tiny, unique particles called atoms that cannot be subdivided.
- Atoms of the same element are exactly alike.
- Atoms of different elements can join to form molecules.

Each element is made up of only one type of atom. It is a substance that cannot be broken down into a simpler substance. For example, Hydrogen and Oxygen are elements, Water (H_20) is not.

O

H

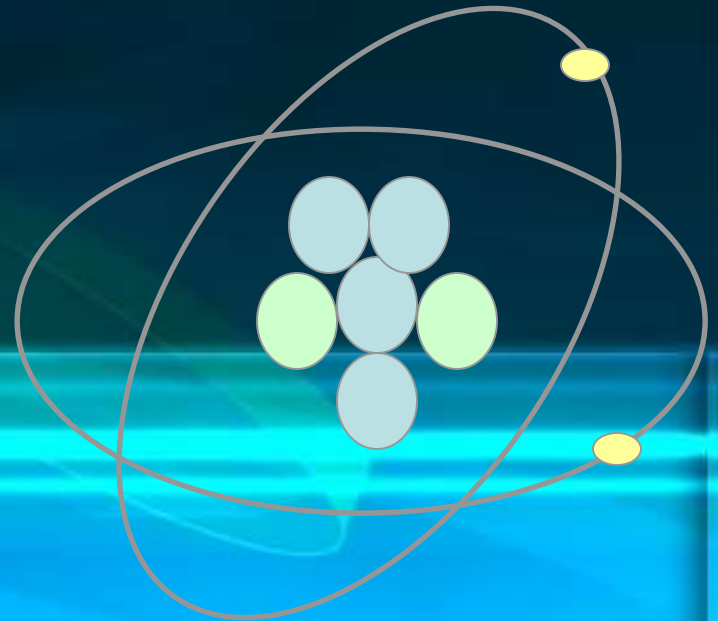
Modern Atomic Theory

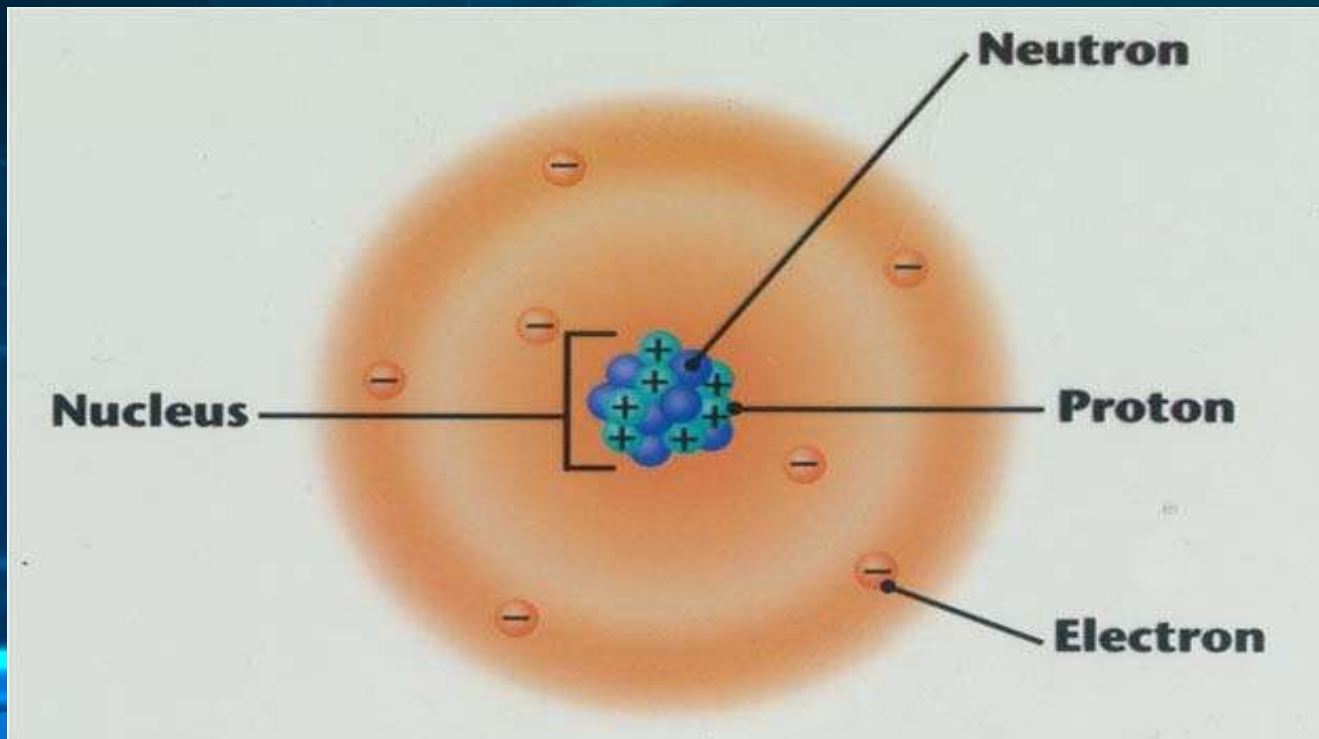
- Today, we know that atoms actually CAN be broken down into simpler particles.
- Specifically, atoms can be broken down into two areas consisting of 3 particles.

What’s in an Atom?

- The atom itself is made up of even smaller particles. The particles differ from each other in their charge (and to some degree their size)
- Protons (positive) (relatively large)
- Neutrons (neutral) (relatively large)
- Electrons (negative) (very small)

Protons and neutrons are located in the nucleus of the atom and make up most of the mass of the atom.

Electrons are very small and are in orbit around the nucleus

What's in an Atom? (cont…)

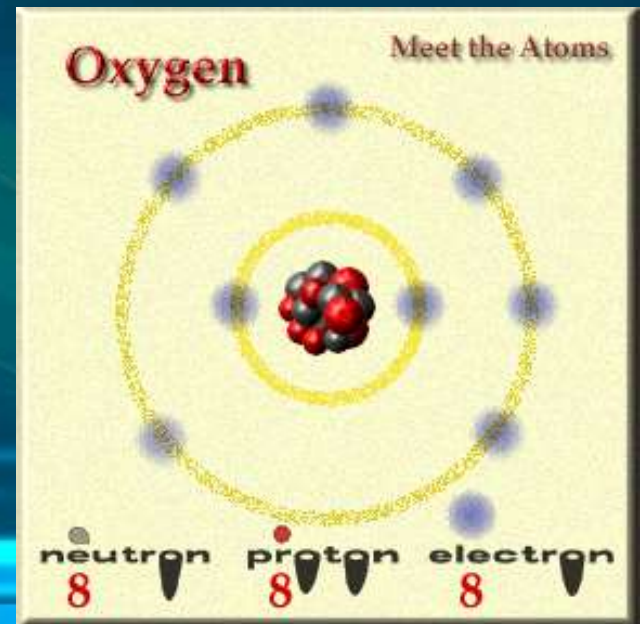
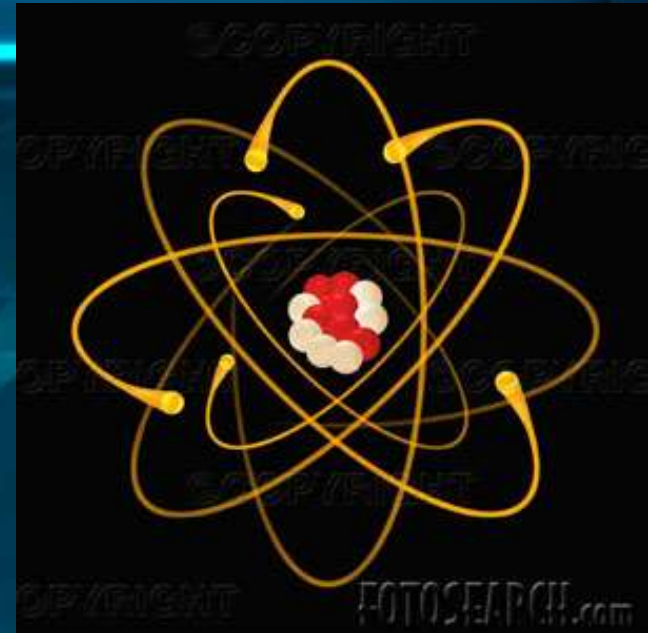
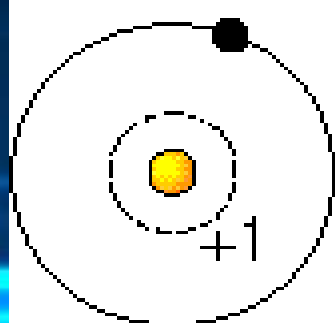
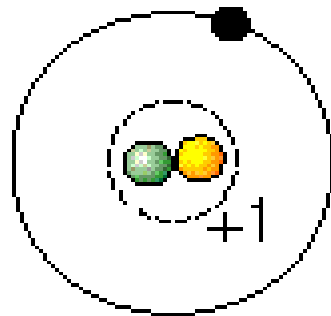
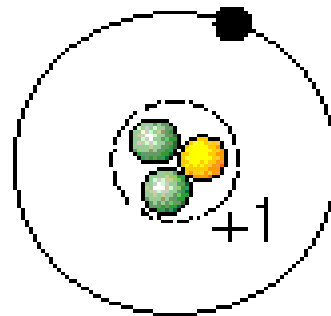
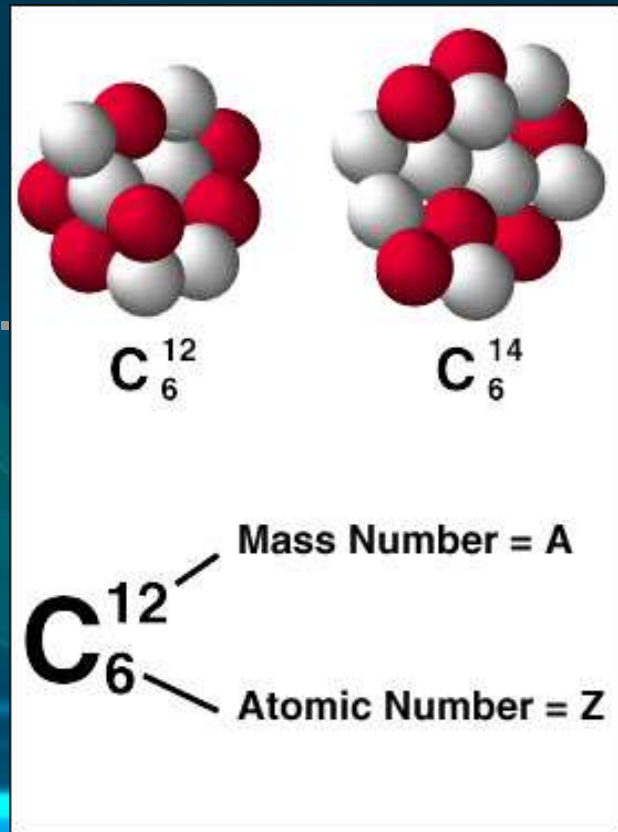
- Atoms have no overall charge.
- In a normal, balanced atom, the number of protons equals the number of electrons.
- Most of the size of an atom is empty space.

The atoms of different elements differ in their number of protons (and when neutrally charged -- which an atom is by definition -- their number of electrons.)

If you look at a periodic table, you will notice that each element has an atomic number. Its atomic number is the number of protons in an atom of that element.

What do protons have to do with electrons? In atoms (which, remember, have a neutral charge) , the number of protons equals the number of electrons. Remember, each proton has a + charge and each electron has a – charge. For an atom to have no charge (neutral) the number of protons and the number of electrons must be equal.

This means, if you know the atomic number of an element, you know the number of protons AND the number of electrons in one of its atoms.

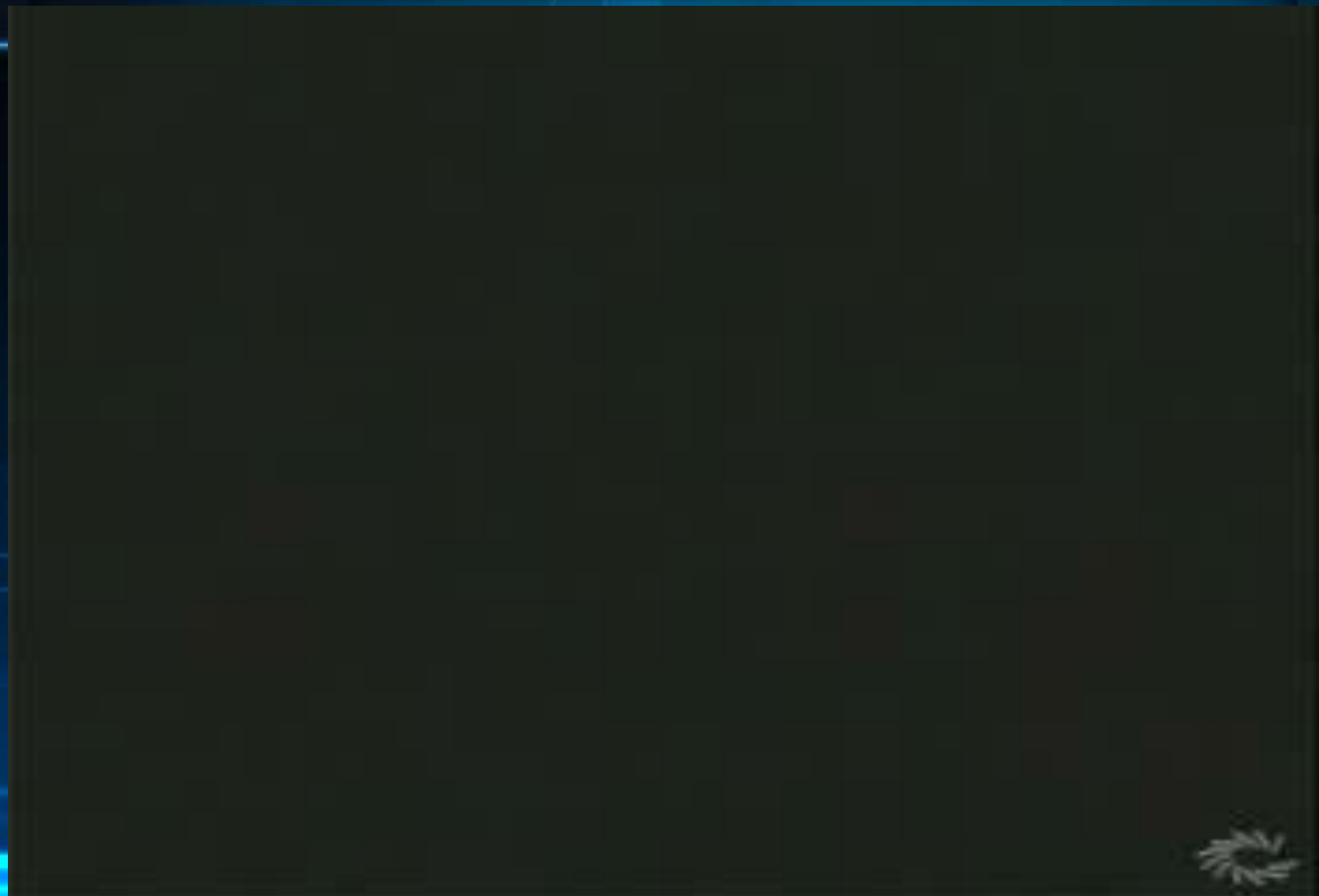
protons = # electrons

- All atoms of the same element will have the same number of protons.
  - All carbon atoms have 6 protons
  - All lead atoms have 82 protons
  - All oxygen atoms have 8 protons

While the atoms of different elements differ in their number of protons, the atoms of the SAME element can differ in their number of neutrons. Atoms of the same element that differ in their number of neutrons are called ISOTOPES.

While the particles of an atom are obviously very small, protons and neutrons are the largest of the particles. They make up the mass of the atom. The mass number of an atom is the number of protons and the number of neutrons added together. The atomic mass is the mass of the protons and neutrons.

Since atoms can differ in their number of neutrons, the atomic mass of a particular element may not be a whole number

- Example: Lithium

^{6}Li	6.015 amu	7.42%
^{7}Li	7.016 amu	92.58%

Avg. mass = 6.015 amu x 0.0742
+ 7.016 amu x 0.9258
= 6.941 amu

Each element has a unique symbol that identifies it.

Ne

Si S

Cu

The Periodic Table

Groups

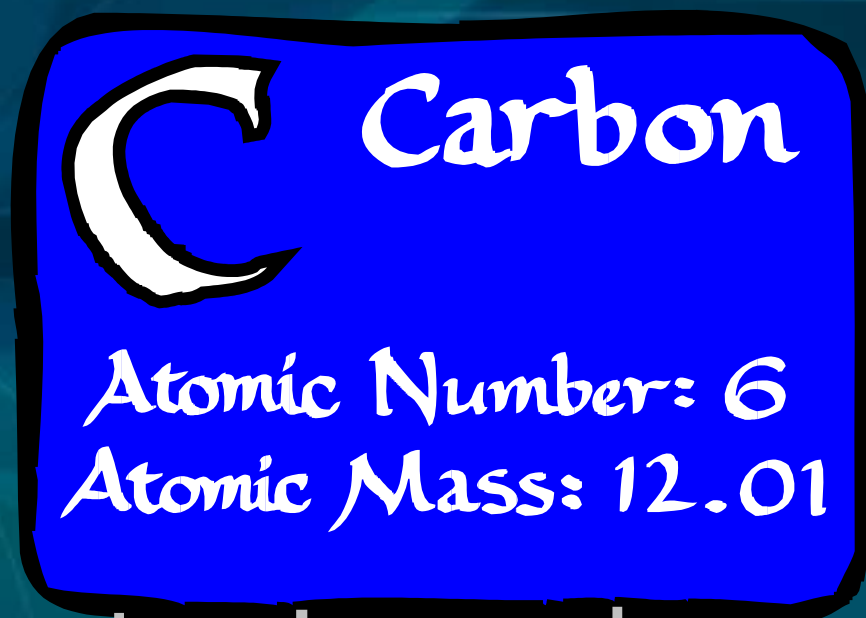
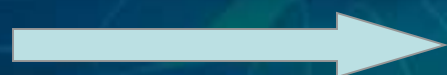
Periods	1	2	3	4	5	6	7	8
1	1 H 1.008							2 He 4.003
2	3 Li 6.941	4 Be 9.012	5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.60

P. 17

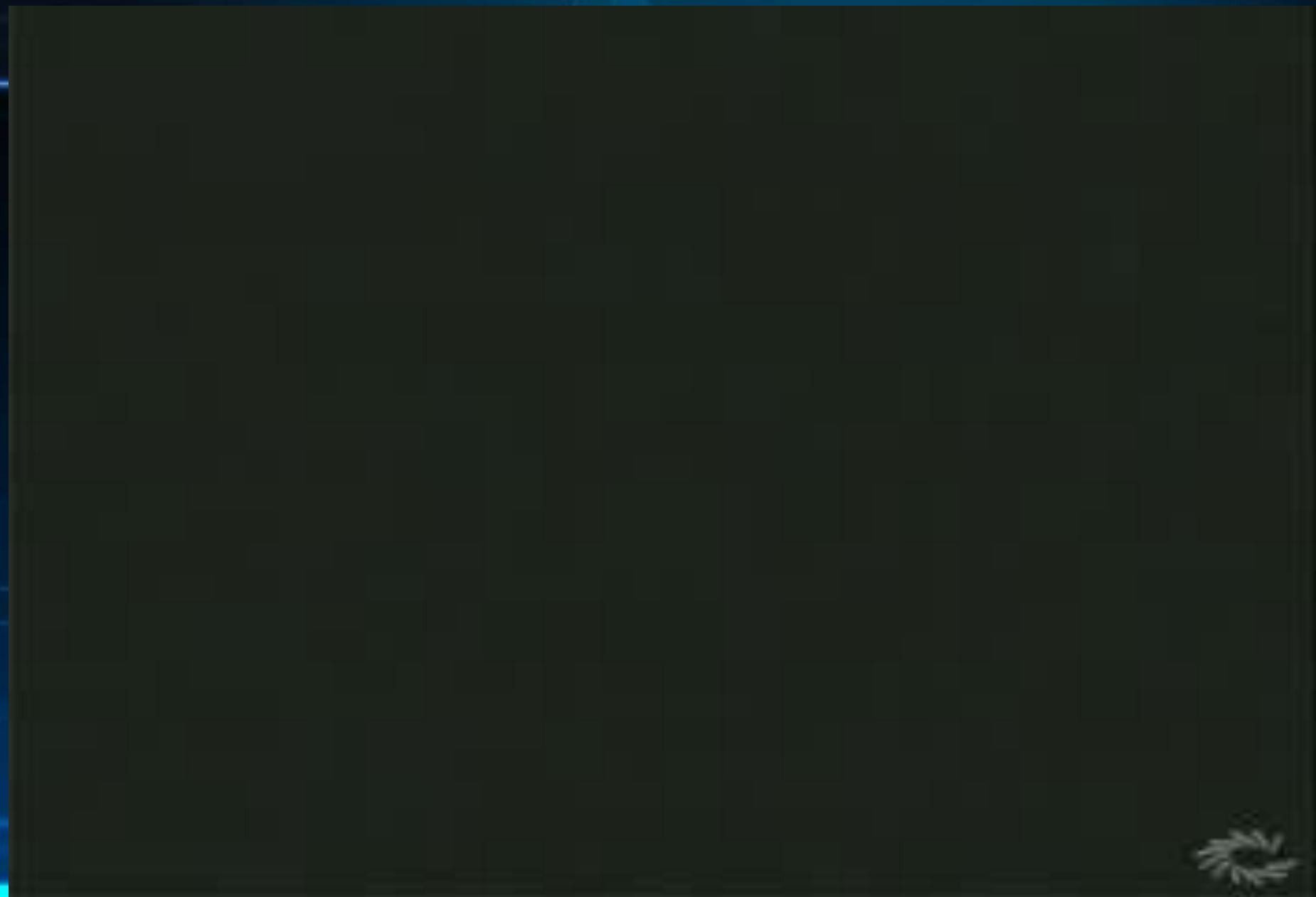
- Sometimes the symbol is easy to recognize: O is oxygen, C is carbon, P is phosphorous, H is hydrogen.
- However, sometimes the symbol is not so easy. For example K is potassium and Na is sodium.

Each element also has a special place on the periodic table.

They are listed in the order of their atomic numbers. An elements place on the periodic table tells you something about its characteristics.

On the periodic table, you can find the elements symbol, atomic number and atomic mass.

Remember, The atomic number indicates the number of protons in the atom.

And the Mass Number is the total number of protons and neutrons.

The atomic mass is the mass of the protons and the neutrons. Since some atoms of the same element can differ in the number of neutrons, the atomic mass is often an average.

Chemical Bonding

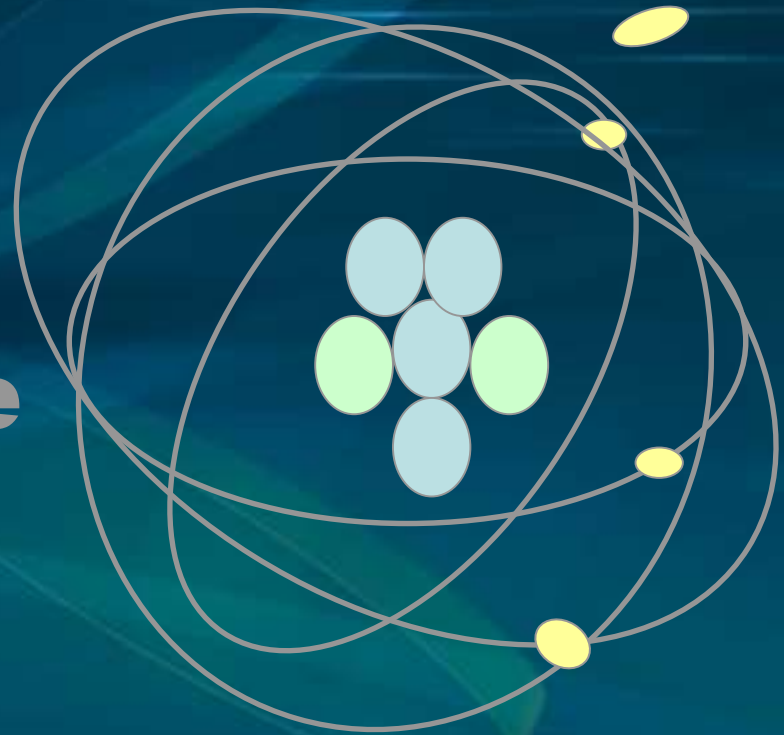
Even though the electrons are very small, they are very important when it comes to chemical bonding.

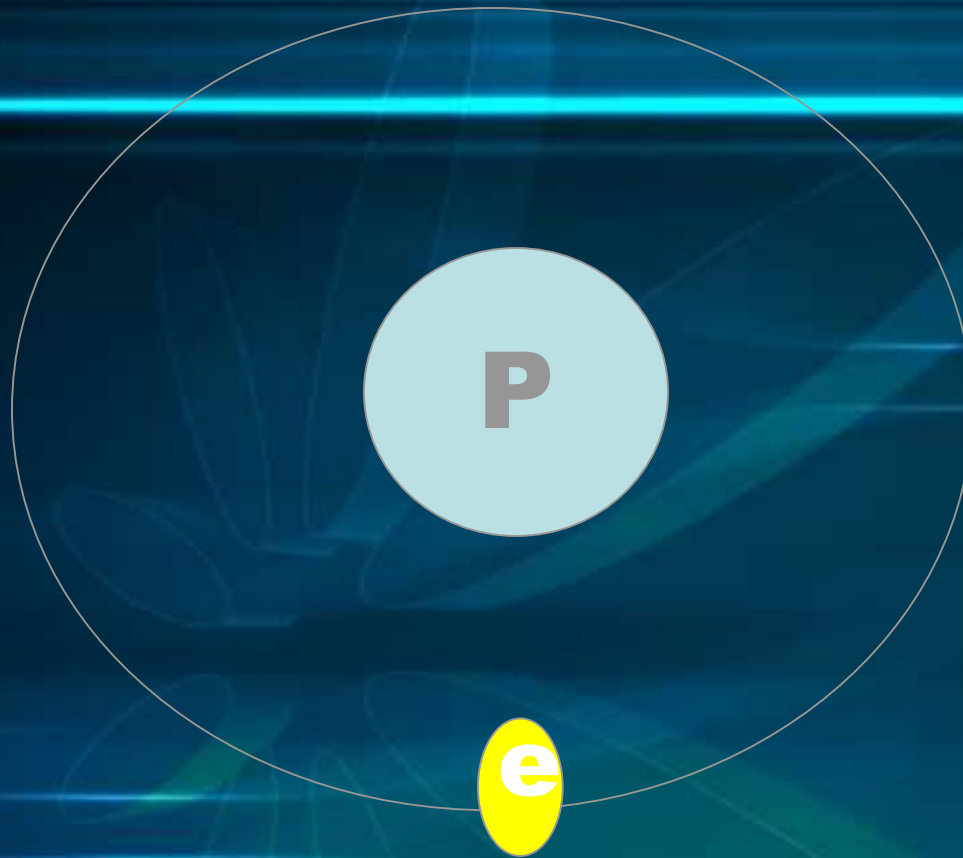
Chemical Bonding forms compunds

Compounds

» A compound is a substance made of two or more elements whose properties are different from those of the elements that make it up.

- Compounds are different from mixtures because the substances which make up compounds are held together with chemical bonds.
- A compound always has the same chemical formula.

As we said, electrons are in orbit around the nucleus, however, they are not all in the SAME orbit.

Electrons fall into different energy levels or "shells". The outermost shell is the valence shell. It is the most important in terms of bonding. For an atom to be stable, it outermost energy level is filled to its electron capacity.

The first shell will hold two electrons, In general, the shells after that follow “the rule of eight”. Think of it as eight parking places around the nucleus. The atom “wants” all the parking places to be full. To do this it might give away electrons, it may gain electrons, or it may share electrons.

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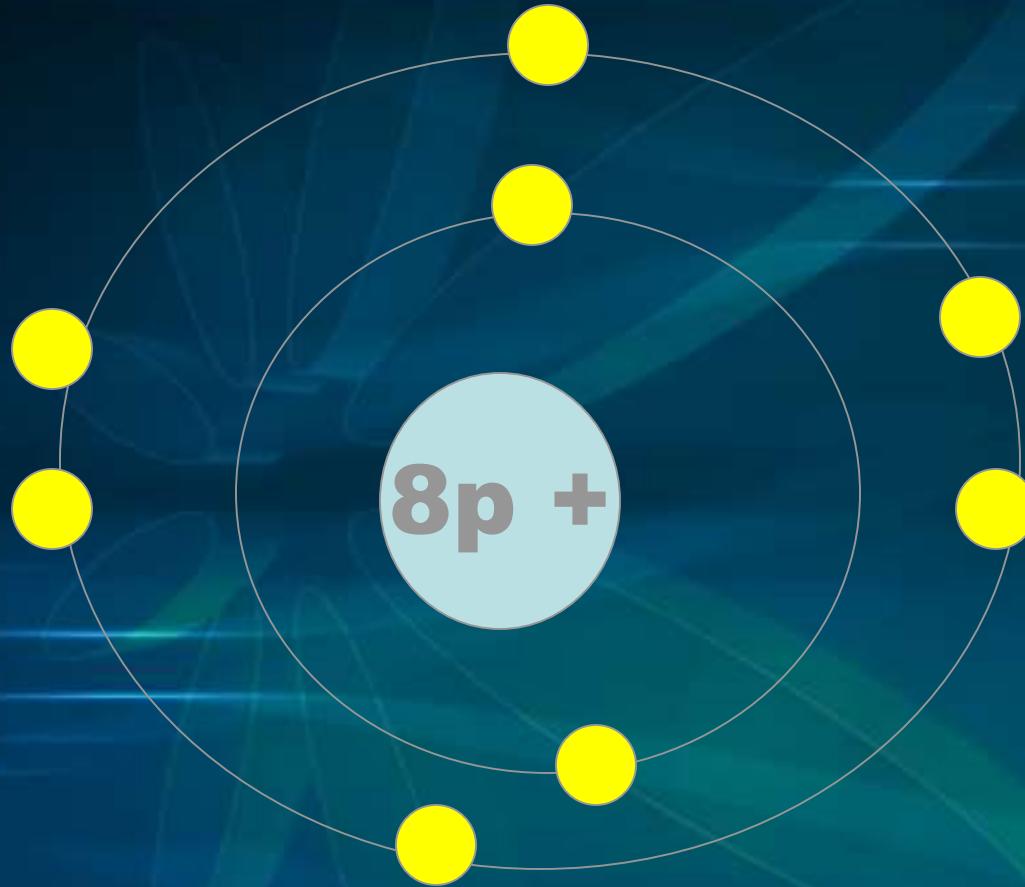
Hydrogen has one proton and one electron. It only has one shell (the one that holds 2 electrons).

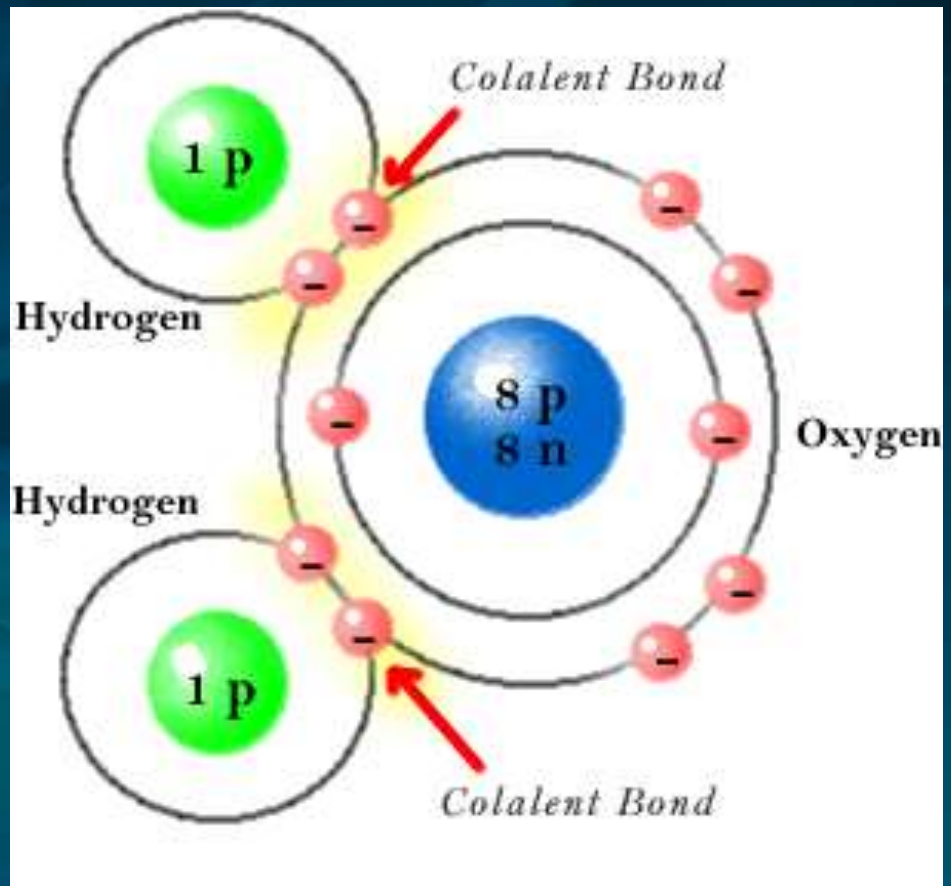
Oxygen has 8 protons in its nucleus

2 electrons in its first shell

Since it has 8 protons it will have a TOTAL of 8 electrons, that means it will have 6 in the next shell

This means, if the outer shell holds eight electrons, there are two “parking places” available

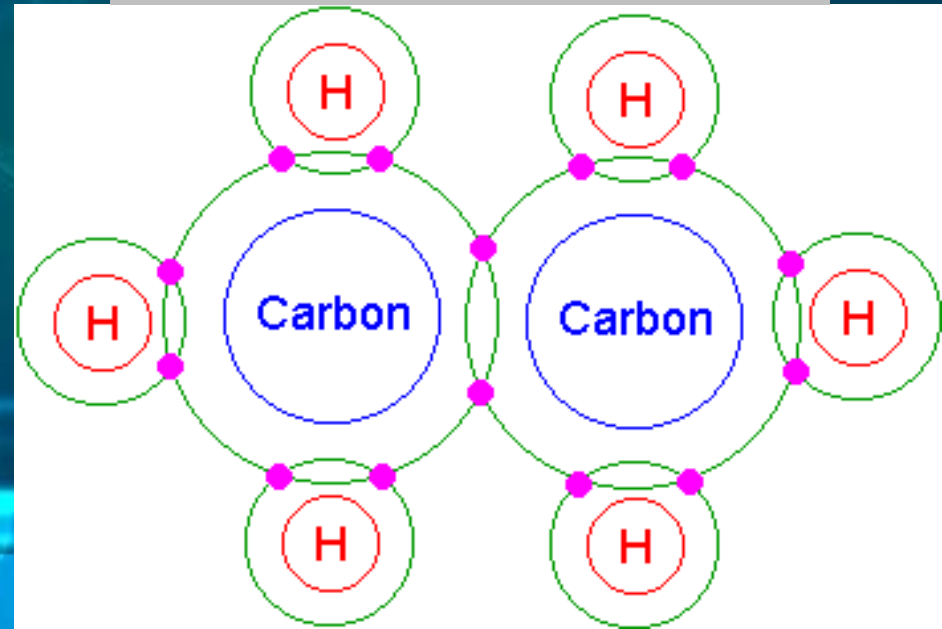
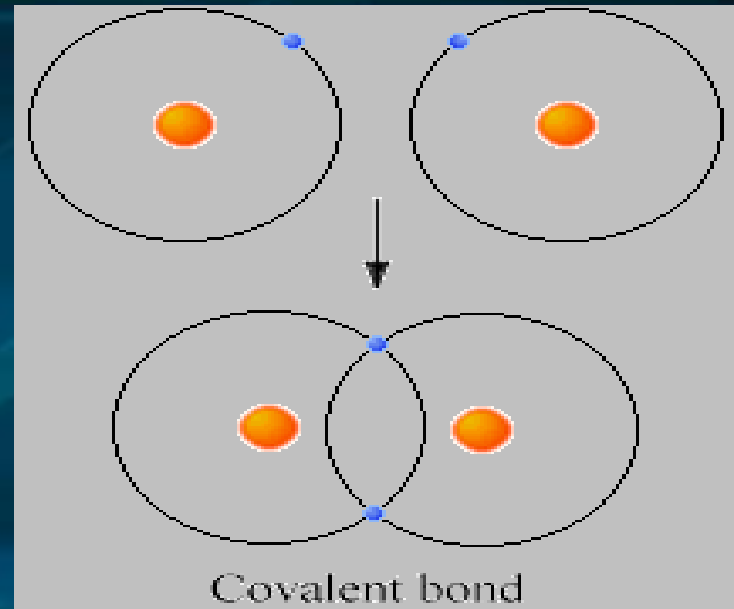
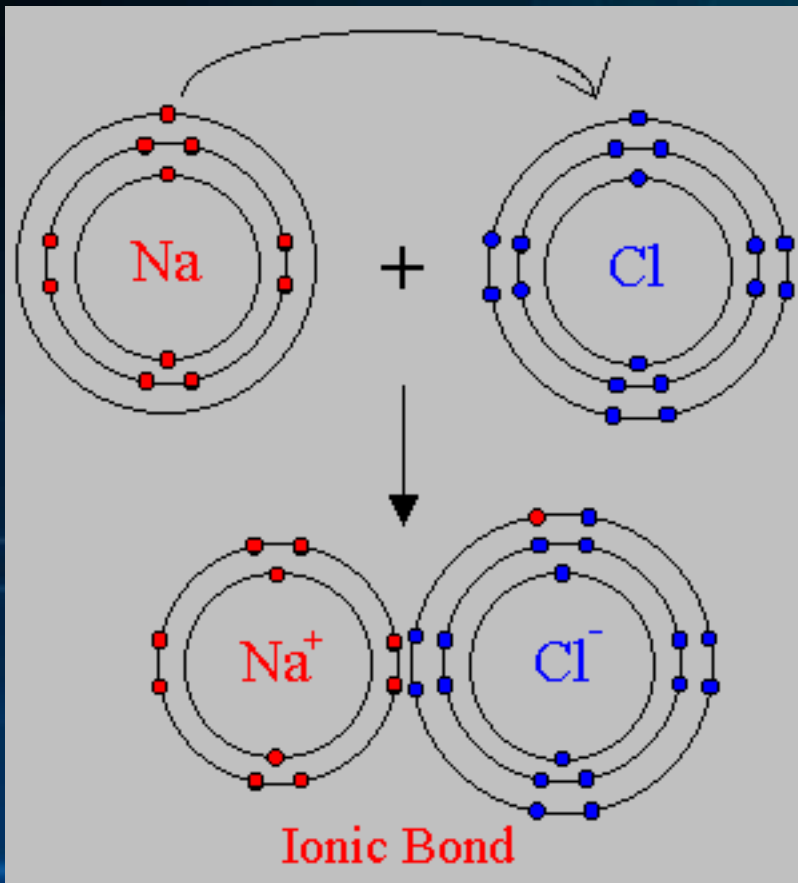
Hmmmm. Hydrogen has one electron available for bonding. Oxygen has 6 electrons in its outer shell and “needs” two more to fill it. I wonder if something could be worked out. What if they learned “its nice to share”.

Water…H_2O forms bonds by sharing pairs of electrons.

By sharing electrons, both atoms are "happy". The valence shells are "filled" They form a stable molecule…. Water!

What are Chemical Bonds?

- Chemical bonds are, in general, interactions between the electron clouds.
- More specifically, the interactions are usually between the valence electrons of the atoms involved. These interactions fill the valence levels of the atoms involved.
- Note that bonds are not rigid structures, but can bend and stretch without breaking, like a spring.
- There are three basic types of chemical bond.

Covalent Bonds

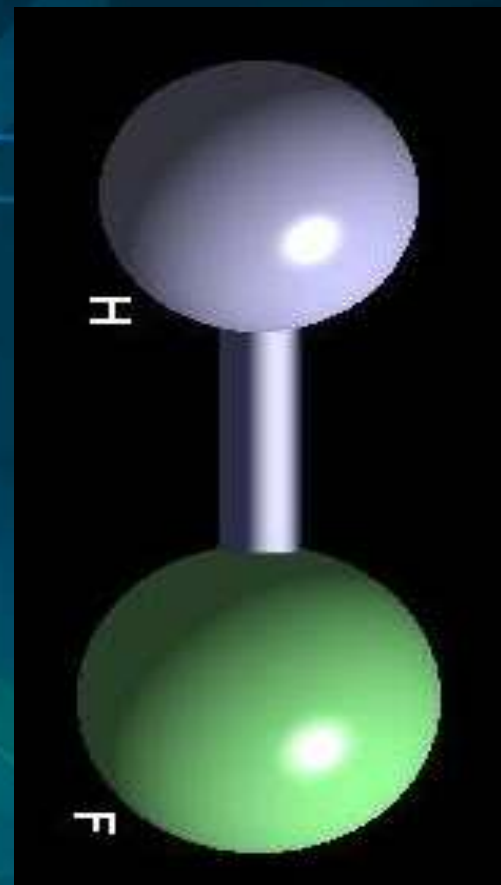
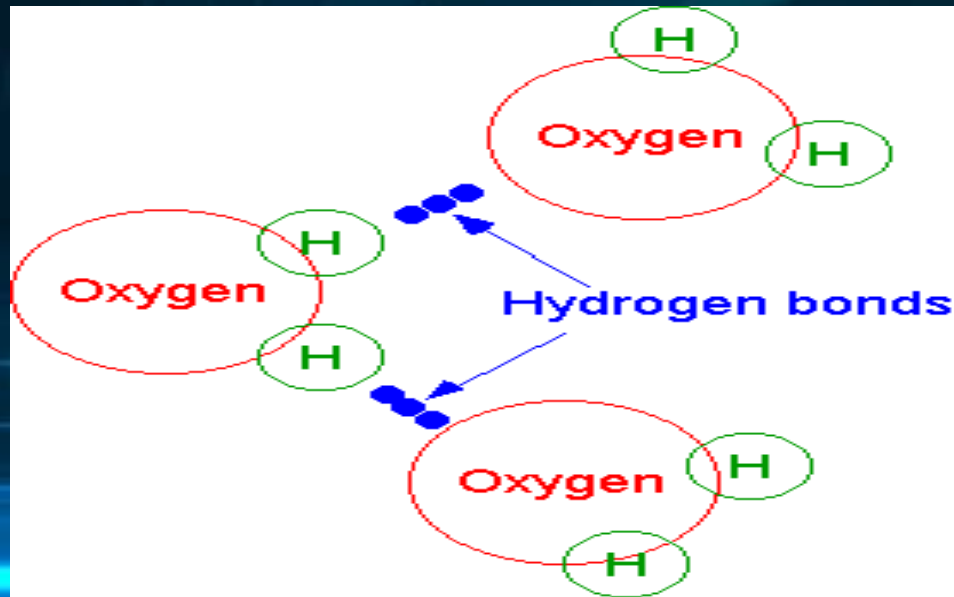
- Bonds formed when atoms share one or more pairs of electrons.
- Usually occurs between two or more non-metal atoms.
- Atoms may share more than one pair of electrons. This allows double or even triple bonds.
- Atoms do not always share electrons equally.

Ionic Bonds

- Ionic bonds are formed between oppositely charged ions, usually between a metal and a non-metal.
  - Metals tend to lose electrons and form positive ions
  - Non-metals tend to gain electrons and form negative ions
- The positive ions attract the negative ions.

When an ionic bond forms, atoms become ions due to losing or gaining an electron.

When an atom **LOSES** an electron it becomes more **POSITIVE** ...remember it is losing the negative electrons. A positive ion is called a **cation**

When a atom **GAINS** electrons it becomes more **NEGATIVE**. Remember, it is gaining more negative electrons. A negative ion is called an **anion**.

It is the attraction of opposite charges between anions and cations that form ionic bonds

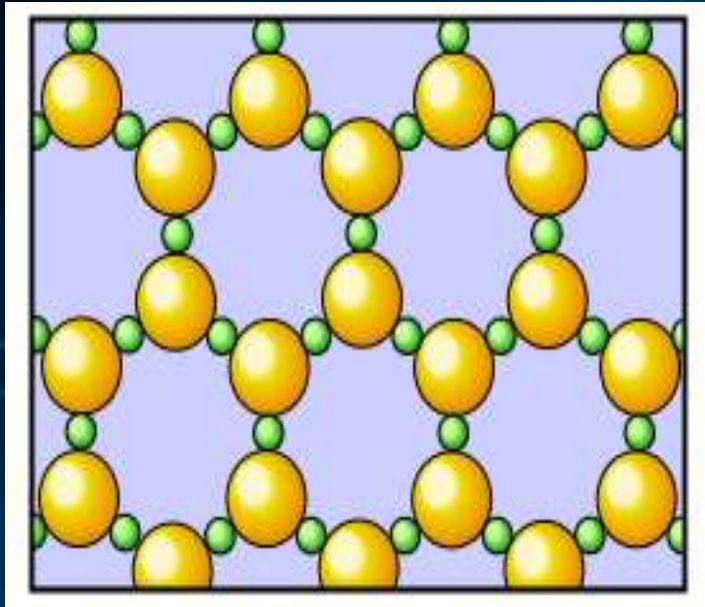
An example of an ionic bond is hydrogen fluoride. When this compound forms, hydrogen loses its electron becoming a hydrogen ion, Flourine gains hydrogen's electron becoming an anion. The + and – charges attract each other, forming an ionic bond.

Hydrogen bonding is the third type of bonding. This bonding occurs between hydrogen (as the name implies) and the negative atom of another molecule.

Hydrogen bonds form BETWEEN two water molecules.

Because of its structure and hydrogen bonding, water has some interesting chemical properties.

Water has a high specific heat and heat of vaporization.

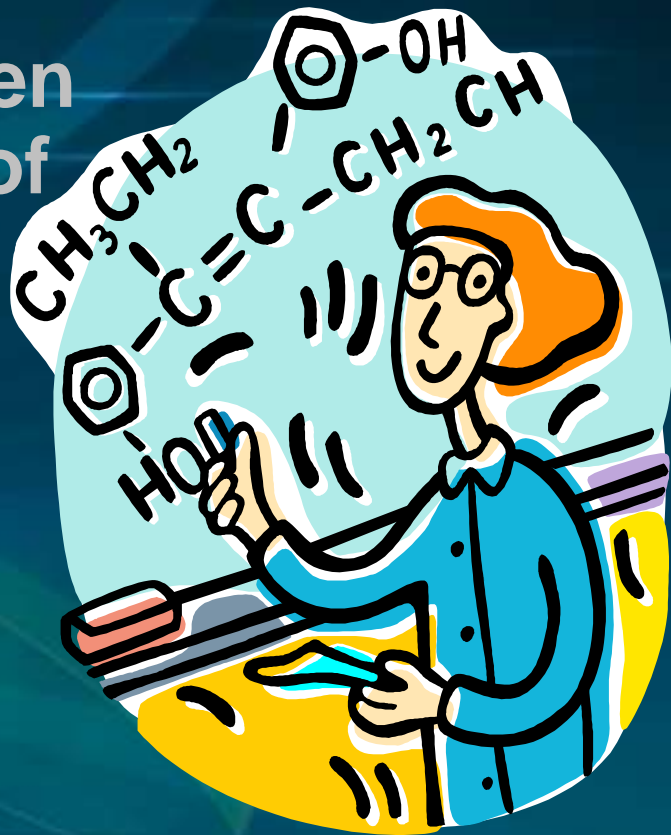
Specific Heats of Some Common Substances

Substance	Specific Heat [cal/(g · °C)]
Water (liquid)	1.00
Water (solid)	0.50
Water (gas)	0.47
Ethyl alcohol	0.54
Wood	0.42
Aluminum	0.21
Glass	0.12
Iron	0.11
Copper	0.09
Silver	0.06
Gold	0.03

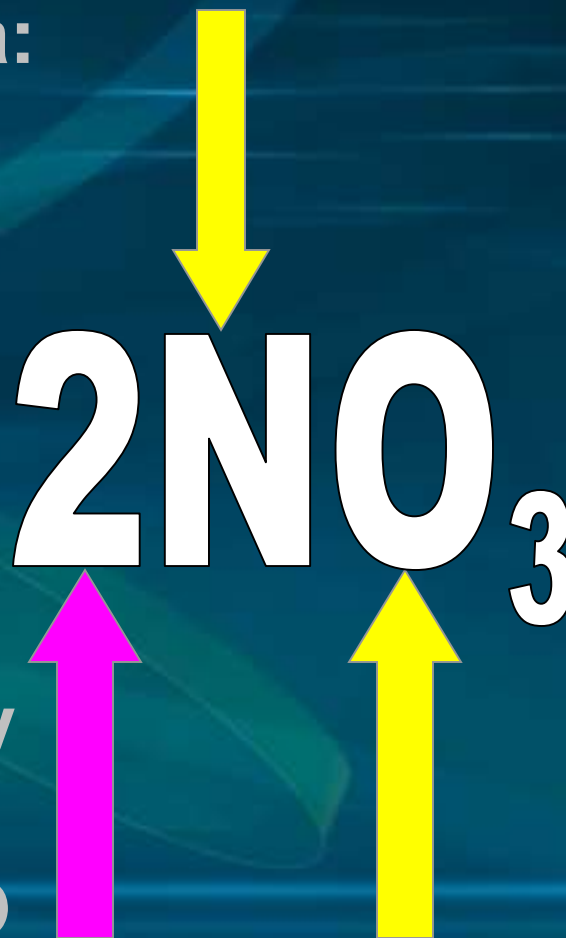
Water is cohesive (sticks to itself and adhesive (sticks to other things)

Water resists freezing, and when it does freeze, it expands

Water is a very good solvent.

Counting Atoms

- A chemical formula is a written way of showing the number of atoms in a compound or molecule.
- Examples:
  - P_2O_5 has two atoms of phosphorous and five of oxygen.
  - $Ca(OH)_2$ has one atom of calcium, two of oxygen and two of hydrogen.

Counting Atoms cont…

- Parts of a chemical formula:
  - **Chemical Symbol**: a one or who letter shorthand for an element – Ca is Calcium
  - **Coefficient**: a number which comes before a formula telling how many of the compound or molecule you have: $2H_2O$ is two molecules of water

$2NO_3$

Counting Atoms cont…

- **Subscript**: a number to the bottom right of the chemical symbol it is modifying, tells how many of that element are in the compound: N_2
- **Parenthesis**: used to surround multiple elements which bond to each other in a different way than they bond to other elements in the compound: $Sr(ClO_3)_2$

$Sr(ClO_3)_2$